Submission in Response to NSF CI 2030 Request for Information

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Title of Submission

Current and Future Needs Rely More On People Than On Technology

Abstract (maximum ~200 words).

People have always been important in science; people are the reason that much research is funded on (human health and advancement), and people are needed to perform that research. Yet, somehow, this human element is often lost or overlooked with respect to cyber infrastructure. People need to know that the infrastructure exists to take advantage of it. They need training to best utilize the equipment available to them. People need to share resources to not duplicate efforts and to build better, more powerful machines that can be used by more people. And those who will use the machines need to be trained in both basic computation and domain-specific computational skills.

We suggest that NSF continues to fund cyber infrastructure, although focusing more on the human aspect. While funding hardware will allow smaller schools to build or enlarge their computing resources, humans are needed to draw these resources and others together in a way that is accessible for the common researcher. Humans are needed to train others in how to use the infrastructure as well as maintain it. NSF would be wise to encourage and fund the human aspect of cyberinfrastructure as well as the hardware.

Question 1 Research Challenge(s) (maximum ~1200 words): Describe current or emerging science or engineering research challenge(s), providing context in terms of recent research activities and standing questions in the field.

Based on feedback from numerous researchers in the science and engineering disciplines, solicited over 3 years (2014-2017), a major cross-cutting challenge was identified. This challenge is the need for current and sustainable scientific computing resources (Cyber

Infrastructure including CI expertise) to accomplish research goals. Scientific computing has become a modern pillar that enables virtually all other science and engineering disciplines. Computational Science represents one of the most important scientific advances in human history. It has transformed forever the way scientific discoveries are made and how engineering design and manufacturing are carried out. It lies at the intersection of mathematics, computer science, and the core disciplines of science and engineering. However, the pace of change in scientific computing as well as the challenges of sustainable cyber infrastructure has overtaken the capacity of individual researchers. The following quotes from two researchers highlight the challenge.

“Technical solutions are often reinvented by researchers working in silos because there are no human resources dedicated to sharing technical solutions and knowledge between research projects. Having this function on campus would accelerate research projects in many disciplines.” (Dr. Brook Milligan, Genomics Researcher)

“The research environment has changed. I am now spending more time working on software, hardware, and network issues, than actual scientific research; however, there is no choice, since my research requires large-scale data analysis in a technology environment that is constantly evolving. What researchers on campus need is a high level person that can help us optimize the technology environments we need for research.” (Dr Jim Kroger, Neuroscience Researcher)

Historically many researchers were able to be self-sufficient in regard to scientific computing resources and expertise within their own silos; however, as the complexity and pace of change, related to computational science has increased, the need for more systemic strategies for Cyber Infrastructure has become an imperative.

For the rest of this response, Cyber Infrastructure (CI) will be defined as the technological and sociological solutions to the challenge of efficiently connecting computers, data, and people with the goal of accelerating scientific discovery and engineering design. So both 1) PEOPLE and 2) TECHNOLOGY are important variables.

On the “PEOPLE” side of the challenge, research universities often lack enough CI expertise (people), who work at an enterprise level, to stay current on CI solutions (both on-campus and external), who can work collaboratively with researchers across various disciplines, and are connected with national communities of CI professionals. Historically, central IT services has focused almost exclusively on the sustainability and optimization of computing resources for administrative and instructional purposes, and have left researchers to develop their own independent solutions. This approach has often led to the research priorities not being represented within the University's decision-making processes. As a result, individual researchers are adrift with respect to seeking and implementing solutions to their scientific computing needs. This often leads to extremely inefficient and ineffective use of scientific computing resources that end up NOT being shared within the research community, or sustained for other various research related purposes (e.g. CI literacy for graduate and undergrad students). It seems that the historical institutional cultures (and national CI funding policies) have not supported collaboration by the individual researchers, or by the institution, in ways that could better leverage CI resources.

The lack of enough CI expertise (people) also contributes to the lack of computational and data (CI) literacy at all levels starting with researchers, but extending to graduate students, undergraduates, and the university administration. This lack of CI literacy has a cascading impact upon the quality of STEM students graduating from the institution attempting to be competitive in their field of study. Additionally, without a strong CI culture within universities, there is a lack of guidance (expectation) related to the STEM preparation occurring in secondary education leaving high school graduates unprepared. The lack of CI literacy of students who are entering the STEM pipeline hampers their ability to traverse between disciplines since they lack transferable core CI skills. The lack of CI literacy among potential STEM mentors further inhibits the success of students entering STEM. Improving CI literacy broadly is a daunting challenge, but incentivizing a collaborative CI culture between researchers and central IT within universities and creating more CI experts as mentors, is a good place to start. This will produce more shared CI resources (including expertise), and open up many more opportunities to expand CI literacy among a broader set of students and other audiences.

On the “TECHNOLOGY” side of the challenge, this would be the hardware and software resources for data acquisition, analysis, presentation, and storage/archival within a broad range of STEM disciplines. While there will always cases where specialized CI is required for some research; however, there is a significant amount of CI resources useful to many disciplines that could be shared. The challenge becomes; 1) how to change culture and policy to incentivize sharing CI resources and; 2) ensure that shared CI resources are effective for research needs. The challenge again points back to the need to have the right people resources in place that can connect researchers, central IT, and university leadership around the priories of STEM research and the associated CI technologies. When the right people are not in place there is often no one focused on changing institutional culture or policy to support shared and responsive CI resources.

Technology needed for effective research exists at different levels, including at the individual researcher’s desktop (or lab), then at the institutional level, and then externally at national centers for technology resources. Again CI Experts, hardware, and software resources are needed at the institutional level to architect the best ways to bridge the levels of technology to address the needs of research at different stages of development. If CI is architected well, then shared CI technology at an institutional level can also act as a “Stepping Stone” environment that facilitate to larger scale national resources. Many disciplines would be transformed by a “Stepping Stone” environment, bridging the gap between a personal desktop and the national HPC super clusters, enabling researchers to obtain results (currently impossible) that strengthen their academic publications and write nationally competitive research proposals. The development of larger campus HPCs that are influenced by the design of larger HPC environments at national centers would offer a training ground for researchers of all levels and serve as an easy transition to national resources. If this type of “Stepping Stone” environment could be made available and robust enough, then it could address different user needs: novice users, who need help working on the command line, to intermediate users, who wish to increase the speed at which their research progresses, to advanced, who need a testbed for their code before running on the national clusters. Given the range of ability and familiarity with HPC systems across campus, an increase of central shared HPC resources would also be a catalyst for greater collaboration between knowledgeable researchers and novices.

Therefore, as stated earlier, both 1) PEOPLE and 2) TECHNOLOGY are important variables related to the challenges faced by STEM research.

Question 2 Cyberinfrastructure Needed to Address the Research Challenge(s) (maximum ~1200 words): Describe any limitations or absence of existing cyberinfrastructure, and/or specific technical advancements in cyberinfrastructure (e.g. advanced computing, data infrastructure, software infrastructure, applications, networking, cybersecurity), that must be addressed to accomplish the identified research challenge(s).

Suggestion: Continue to issue NSF grant solicitations to continue strengthening the role of institution-wide CI Experts (e.g. CI Engineers). This role is absolutely needed to address the challenges of creating more shared CI resources and a more collaborative culture between disciplines. This role will advance a national network of CI professionals focused on bridging CI resources from the researchers’ desktops, to the institutional-level, to the national level resulting in much more efficiency and effectiveness of CI to accelerate research and design results.

Suggestion: To address Technology Challenge (getting people to share), for any NSF solicitation utilizing CI resources, include requirement (or encouragement) to include an institutional-level CI expert (or CIO) as senior personnel on proposals. Perhaps also include a national CI expert if the proposal will utilize a national CI center as part of the research.

Suggestion: To address Technology Challenges (getting people to share), for NSF solicitations that include hardware (e.g. HPCs) adding requirements that would incentivize researchers to have a plan for sustainability and sharing of hardware, and have them include central IT (or a similar entity) in the planning stage (e.g. letter of support from CIO). Also, encourage budget participation in shared CI resources that could have value to STEM research and/or education outside immediate research. Funding strategies need to position the institutions’ CI resources to be responsive to research needs. If the central CI resources are not sized appropriately, up-to-date, and supported correctly, then researchers are encouraged to return to a silo culture.

Suggestion: Continue to issue NSF grant solicitations to improve CI literacy and skill to broad audiences through the leveraging of shared CI resources (incl. Expert mentors and technology).

Consent Statement